sky; the average excess for January, 1896, is 4.4 per cent for photographic records, and 4.5 per cent for thermometric records. The details are shown in the following table in which the stations are arranged according to the greatest possible duration of sunshine, and not according to the *observed* duration as heretofore.

Difference between instrumental and personal observations of sunshine.

Photographic stations.	Possible duration.	Instrumental.	Personal.	Difference.	Thermometric stations.	Possible duration.	Instrumental.	Personal.	Difference.
	H'rs.	%	%	%		*H'rs.*	%	%	%
Galveston, Tex	326.8	45	44	1	New Orleans, La	324.6	42	41	1
Savannah, Ga	320.5	51	39	12	Vicksburg, Miss	320.5	34	32	2
San Diego, Cal	318.5	62	56	6	Atlanta, Ga	316.2	48	44	4
Santa Fe, N. Mex	311.8	77	63	14	Wilmington, N. C	316.2	53	52	1
Dodge City, Kans	306.5	55	47	8	Little Rock, Ark	314.7	40	35	5
Kansas City, Mo	303.7	34	37	— 3	Louisville, Ky	306.5	31	24	7
Washington, D. C	303.8	46	46	0	San Francisco, Cal	306.5	37	35	2
Eureka, Cal	298.4	25	26	— 1	Baltimore, Md	303.8	40	37	3
Salt Lake City, Utah	298.4	40	25	15	Cincinnati, Ohio	303.8	34	34	0
Cleveland, Ohio	295.5	20	23	— 3	St. Louis, Mo	303.8	48	41	7
Eastport, Me	286.8	54	43	11	Columbus, Ohio	301.1	25	20	5
Portland, Oreg. *	283.1	22	31	— 9	Philadelphia, Pa	301.1	57	45	12
Bismarck, N. Dak	279.8	30	35	— 5	New York, N. Y	298.3	48	45	3
Helena, Mont	279.8	41	44	— 3	Boston, Mass	295.5	52	48	4
Phœnix, Ariz	318.3	77	72	5	Chicago, Ill	295.5	35	30	5
Denver, Colo	301.1	80	57	23	Des Moines, Iowa	295.5	49	38	11
					Detroit, Mich	295.5	34	27	7
					Buffalo, N. Y	292.7	21	13	8
					Rochester, N. Y	292.7	49	26	23
					Portland, Me	289.7	62	45	17
					Portland, Oreg.*	283.1	26	31	— 5

* Records kept by both methods.

ATMOSPHERIC ELECTRICITY.

Numerical statistics relative to auroras and thunderstorms are given in Table X, which shows the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month, respectively.

The dates on which reports of thunderstorms for the whole country were most numerous were: 21st, 33; 22d, 35d; 23d, 45; 31st, 27.

Thunderstorm reports were most numerous in Texas, 44; Florida, 33; California, 30; Louisiana, 28; Alabama, 19; Georgia, 16; Mississippi, 15.

Thunderstorms were most frequent in: Texas, 11 days; California, 8; Louisiana, 7; Florida and Mississippi, 5.

Auroras.—The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be the four preceding and following the date of full moon, viz, from the 1st to the 4th, and also the 25th to the 31st, inclusive. On the remaining twenty days of this month 102 reports were received, or an average of about 5 per day. The dates on which the number of reports especially exceeded this average were: 3d, 71; 4th, 23; 5th, 21.

Auroras were reported by a large percentage of observers in: Maine, 126; New Hampshire, 77; North Dakota, 55; Minnesota, 27; Wisconsin, 26; New York, 20.

Auroras were reported most frequently in: North Dakota, 11 days; Montana, 10; Minnesota and Wisconsin, 9; Maine, New Hampshire, and New York, 8.

CANADIAN REPORTS.

No thunderstorms were reported.

Auroras were reported as follows: 2d, Charlottetown, Winnipeg; 3d, Quebec, Montreal, Rockliffe, Toronto, White River, Minnedosa, Prince Albert; 4th, Rockliffe, Toronto, White River, Port Arthur, Winnipeg, Prince Albert; 5th, St. Andrews, Toronto, White River; 6th, Father Point, Quebec, Minnedosa; 8th, Minnedosa, Medicine Hat; 9th, Montreal; 10th, Medicine Hat; 11th, Battleford; 13th, Minnedosa; 14th, Father Point, Minnedosa, Medicine Hat, Prince Albert; 15th, Father Point, Port Arthur; 16th, Port Arthur, Minnedosa, Edmonton; 17th, St. Andrews, Minnedosa; 18th, Father Point, Minnedosa, Battleford; 19th, Quebec, Minnedosa, Edmonton; 20th, Minnedosa; 21st, Father Point, Medicine Hat; 26th, Prince Albert; 29th, Medicine Hat; 31st, Yarmouth.

INLAND NAVIGATION.

The *extreme and average stages of water* in the rivers during the current month are given in Table VIII, from which it appears that the only river that rose above the danger line was the Sacramento, at Red Bluff, on the 29th.

ICE IN RIVERS AND HARBORS.

The charts of depth of snow on the ground and thickness of ice published weekly by the Weather Bureau show that by Monday, January 6, much ice had formed on the Great Lakes, the upper Mississippi and Missouri rivers; there was a general increase in thickness throughout the month and on Monday, January 27, the thickness in inches was about as follows:

Missouri River.—Miles City, 16; Williston, 25.5; Bismarck, 30; Pierre, 19; Yankton, 18.5; Sioux City, 15; Omaha, 10; Kansas City, 2.0.

Red River of the North.—Moorhead, 30.

Upper Mississippi.—St. Paul, 17; La Crosse, 15; Dubuque, 10.5; Davenport, 9; Keokuk and Hannibal, 0.

Hudson River.—Albany, 11.

Lake Superior.—Duluth, 21.5; Sault Ste. Marie, 7.

Lake Michigan.—Green Bay, 13; Milwaukee, 6; Chicago and Grand Haven, 0.

Lake Huron.—Alpena, 9.5; Port Huron, 6.0.

St. Clair River.—Detroit, 12.

Lake Erie.—Toledo, 4; Sandusky, 4; Cleveland, 4; Erie. 7.5; Buffalo, 4.

Lake Ontario.—Oswego and Rochester, 4.

METEOROLOGY AND MAGNETISM.

By Prof. FRANK H. BIGELOW.

It has been found expedient to make a further modification in the presentation of the meteorological and magnetic data, showing the approximate synchronisms in the two types of elements, beginning with January, 1896. This is in part due to the action of the vertical-force magnetometers at Washington and Toronto, which are both affected by magnetic waves from the neighboring trolley-line systems, and also, in part, to the improved operation of the new "magnet-watch," used as an integrator of work in the varying terrestrial magnetic field. The encroachment of trolleys into the neighborhood of our permanent magnetic observatories causes great injury in this branch of science. There seems to be no way to compensate this action without shutting off too much of the terrestrial field by excessive damping, and in that case the variations are greatly obscured. Fortunately the horizontal components, from the bifilar and the declinometer, are much less disturbed, inasmuch as the magnetic lines induced by the trolleys enter the earth along the normal, or very nearly so. The synchronism of the horizontal components at Washington and Toronto continues to be valuable; but in the vertical component the amplitudes derived from the data show very different sensitiveness, and the sequence of crests is also very irregular at times. This misfortune, falling upon our observatories, is to be deplored, but it can not be avoided, unless by removal of the instruments to locations far from all electric lines. In San Antonio, Tex., the same difficulty was encountered 3 miles from the trolley line, and it was found that such disturbances could be detected for a distance of 20 miles. Accordingly our computation has been modified by omitting ΔV, dz, s, and a, all of which depend upon the vertical force.

THE NEW MAGNET-WATCH INTEGRATOR.

During the past two years some experiments have been in progress, looking to the perfecting of an apparatus which shall be simple to operate, inexpensive, and at the same time able to record the *relative variations* in the external terrestrial magnetic field with considerable accuracy. It is now believed that we have such an instrument, and that the fundamental principle upon which it is constructed is capable of important developments. The Weather Bureau could adopt only that type of apparatus for general use at its stations which admitted of observations as simple as those of a barometer or thermometer. The expense of installing and operating first-class magnetic observatories makes it quite impracticable to consider a plan embracing more than three magnetic stations. It will always be necessary, even with successful secondary apparatus, to have some primary observatories for the measurement of absolute values, and for control upon the values from the adopted secondary instruments. A proper arrangement would be three first-class magnetic stations, one in the East, one in the Mississippi Valley and one on the northern Rocky Mountain Plateau, together with a magnet-watch integrator at each of the telegraphing stations of the service from which daily reports could be forwarded. In this way the local conditions of the field could be studied. At present, with one instrument at Washington only, it is impossible to do more than to indicate the fact that there is an important system of forces to be considered, which apparently have much to do with the building up of weather conditions, especially in the northwest. A record of the magnet-watch for January, 1896, is introduced in place of the data excluded on account of the imperfections of the vertical force observations. My attention was first called to the possibility of developing a new principle for the measurement of the variations in the intensity of the terrestrial magnetic field by Mr. F. H. Hesse, Salt Lake City, Utah. He related that by accident his watch became heavily magnetized, and that its rate then varied from day to day through such wide ranges, that it attracted his attention and excited his interest to observe it carefully. A comparision was made by him with a well regulated chronometer. The daily losses or gains in seconds were tabulated and plotted as ordinates on a base whose unit of length was twenty-four hours. The resulting curve, or broken line, was found to have sufficient similarity with the mean curve that I published in the MONTHLY WEATHER REVIEW for the normal intensity curve of the solar field, presented to the earth with each synodic revolution of the sun on its axis, to induce him to send the record to the Weather Bureau, with the request that the subject be fully investigated.

It seemed to me at the time that the germ principle was correct, and might possibly be utilized, if a suitable apparatus could be procured. Evidently such a mechanism can be regarded as a true integrator of work done in a varying magnetic field, the energy expended being derived from two sources; first, the elastic or molecular energy of the watch spring, going out as a constant total every twenty-four hours, or nearly so, corresponding to the perfection of the watch itself; second, the vibrating impulse of the magnetic field on the magnet, which would in the course of twenty-four hours amount to a certain number of seconds, depending upon the strength of the field. If the mechanism is good, then the variation in the number of seconds, marked off by the watch, can be taken as a measure of the mean intensity of the field itself for the elapsed interval of time. By comparing the variations in the watch rate with the variations in the field as given by the magnetometers, the value of one second in dynes can be found. This value is not a vector quantity, as it lacks the directional element, but for the purposes in view by the Weather Bureau that is not needed.

Our efforts to perfect the apparatus can be briefly narrated. A watch was procured, magnetized by contact with a steel magnet, and its record was found promising, but not satisfactory. The form of the ordinary balance wheel, being such as to bring the two poles back nearly to the center, is extremely bad. The two metals comprising the rim, with the compensation weights, leaves little metal for the magnetism; also the steel is too soft to retain permanent magnetism. Much unreliability is therefore inherent in the common watch, and the performance was necessarily disappointing.

For the period of about a year, Mr. James P. Hall, of Brooklyn, N. Y., cooperated with me in a series of observations on two similar watches, with the view of ascertaining whether synchronisms of rate variation would be found in New York City and Washington, D. C. We had a similar partial success, but not enough to feel that the indications were reliable measures of the variations of the magnetic field.

Finally, I stated the case to Prof. Dr. Th. Edelmann, Munich, and he constructed the modified watch-magnet, whose record it is proposed to publish as evidence that we have in hand a fruitful type of germ apparatus for magnetic variations, when the relative values for a given interval, and not the absolute values at certain epochs are required. The balance wheel was removed from a Charmilles, Geneva watch; the spindle to the escapement was lengthened to about 18 millimeters, with suitable support in the standard; for the balance a hollow cylindrical magnet of the same moment of inertia as the original wheel was substituted, length, 20 mm., diameter, 3 mm., thickness of steel, about ½ mm. There is no temperature compensation; the case is nonmagnetic, also all the material except the chain and springs. When running, the watch is laid on a shelf which is midway between two vertical soft iron bars, 22½ cm. long and 2½ cm. in diameter, placed end on, 4 cm. apart, along the axis of the bars. The effect is to cause the vibrations of the magnet to pass at right angles to a field induced by the earth's field, and varying in intensity with it. The iron bars concentrate the external field and give it a constant direction at the magnet. The watch is wound twice daily, at 8 a. m. and 8 p. m. The standard time is obtained from the noonday signals of the U. S. Naval Observatory, and an accurate comparison of the watch is made. The January record is found on Chart V. The first curve gives the relative variations of the horizontal component of the earth's magnetic field, as determined at Washington and Toronto; the second, the variations in the rate of the magnet watch; the third, the variations in the pressure for the stations in North Dakota and South Dakota, and Canada, as explained in the MONTHLY WEATHER REVIEW, January 1895, page 7; the fourth, the variations of temperature in the same locality.

Making a comparison of these curves, as heretofore described, we infer that it is the synchronism in the minor crests that is apparently due to the magnetic field, the longer curvatures being more properly attributed to the convectional meteorological system. In the watch curve, the slope is approximately eliminated by the method of plotting the daily gains and losses on a zero line. The watch does, however, record long-range variations, since, by extending our inspection to the record of the subsequent February, March, and April, it is found that its hour hand has retreated to about 11h. 40m. for noon, and advanced again to 12h. 00m. This movement has occurred several times in addition to the system of minor fluctuations that appear on curve No. 2. The rate of the watch is occasionally decidedly changed in 24 hours, since about 300 seconds may be gained or lost on the normal run in a single day, and smaller values are also recorded for other days. The most promising feature of the experiment is this large measurable quantity which may ultimately be of much service in determining latent weather forces.

When all these curves are compared among themselves, the general relations of the magnetic and meteorological forces can be defined. The data of the horizontal component, shown in curve No. 1, Chart V, is that which evaluates the changes in the intensity of the resultant of the combined terrestrial and solar magnetic fields. Now, according to my conception of the fundamental phenomena, these changes are due to certain equivalent solar impressed forces, which I call polar and equatorial radiations, and which are equal to the residuals given in curve No. 1, on Chart V, but with *reversed sign*. Hence we have the law that an *increase in the intensity of the solar* magnetic output, approaching the earth from the north to the south side of the ecliptic, corresponds (1) to an *increase in the march of the watch rate*, the magnetic field being stronger; (2) to an *increase in the barometric pressure of the atmosphere*, especially in the arctic and the subtropical magnetic belts; and (3) to a *decrease in the temperature* of the same regions. That is to say, years or seasons of *increased solar output give higher arctic pressures and lower temperatures*. Extending this backward to geological periods, the Glacial epochs corresponded to increased solar action, which lowered the temperature in the arctic regions. These become, therefore, measures of the longest solar period known to us.

In current meteorological phenomena, "highs" seem to be built upon the west Canadian plains by an increase in the intensity of the sun's polar magnetic field. They are then caught up in the earth's convectional system and transported eastward in the northern or the southern circuits. The running down of these highs, under gravitation, produces a system of lows, with cyclonic movements, on their periphery, or between two adjacent highs with counterflowing currents in the lower strata of air. Similar functions may, to a much smaller extent, be attributed to the tropical highs, but the agency of the solar equatorial field obscures this operation, except, perhaps, in the case of hurricanes, considered as a phenomenon embracing many years. In order to successfully trace these functions throughout the globe, our knowledge must be much increased. Even in the northwest, where the operation of the polar field is pronounced, the intermingling of the effects of the polar and equatorial radiations causes much looseness of synchronism. The intermittent nature of the rate of the eastward drift is the chief factor in that irregularity, but even so, by paying attention to the minor curvatures, it is easily discovered that such a system of forces as described is constantly at work upon the atmospheric elements. A close detailed comparison of the temperatures and pressures of the northwest, as given on the daily weather map, extended over several years, not only confirms the accuracy of the adopted period of solar rotation, but also the view that has been explained as our working hypothesis.

CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Division.

The following extracts in regard to the general weather conditions in the several States and Territories are taken from the monthly reports of the respective services.

Snowfall and rainfall are expressed in inches.

Alabama.—The most noticeable characteristics of the climatic conditions for the month were a very general and severe cold wave from the 3d to 6th, which spread over the entire State, giving freezing temperature as far south as the Gulf Coast. The mean temperature was 44.1°, or 1.2° above the normal. The highest, 78°, was recorded at Tuscaloosa on the 31st, and the lowest, 9°, at Decatur on the 4th. The average precipitation was 4.25, or 1.11 less than normal. The greatest monthly amount was 8.71, at Healing Springs, and the least, 1.77, at Daphne.

Arizona.—The mean temperature was 47.7°, or about 8° above normal. The highest, 90°, at Maricopa, and the lowest, 4°, at Flagstaff. The average precipitation was 0.55, or about 0.44 below normal. The greatest amount was 2.00,at Reymert, and the least, 0.00, at San Simon and Texas Hill.

Arkansas.—The mean temperature was 41.4°, or 3.2° above normal. The highest was 78°, at Elon on the 31st, and the lowest, 4°, at La Crosse on the 4th. The average precipitation was 4.09, or normal. The heaviest falls were reported from the central parts of the State, and the lightest were generally in the extreme northern portion. The greatest amount was 6.94 at Camden, and the least, 1.32, at Dardanelle. There were about 50 per cent more cloudy days than usual.

California.—The mean temperature was 50°, or 4.4° above normal. The highest was 112°, at Salton, in the desert region, on the 21st, and the lowest, 8° below zero, at Boca on the 22d. The average precipitation was 8.45, or 3.93 above normal. The greatest monthly amount was 45.17, at Lagunitas, 6 miles from San Rafael, Marin County, and the least, "trace," at Barstow, in the desert region of San Bernardino County.

Colorado.—The month was unusually warm over the entire State. Comparison with the normal shows that there was an average excess of about 5° daily in the western counties and the San Luis Valley, and from 7° to 10° over the mountain districts and the eastern Slope. The highest temperature was 75°, at Downing on the 5th, and near Crook, Logan County, on the 19th; the lowest, 24° below zero, at Gunnison on the 5th. The average precipitation was 0.81, or 0.12 below normal. The greatest monthly amount was 7.69, at Ruby, Gunnison County, and the least, "trace," at Byers, Arapahoe County.

Florida.—The mean temperature was 56.5°, or 4.5° below normal. The highest was 93°, at Tampa on the 30th, and the lowest, 20°, at Milton on the 5th. The average precipitation was 3.96, or 0.55 above normal. The greatest monthly amount was 8.01, at New Smyrna, and the least, 0.45, at Lemon City. Several severe cold waves passed over the State; the most severe one reached the State on the night of the 4th, and its influence was felt on the 7th as far south as Jupiter.

Georgia.—The mean temperature was 44.4°, or about 1.0° above normal. The highest was 75°, at Poulan on the 30th, and the lowest, 5°, at Diamond on the 4th. The average precipitation was 4.11, or about 0.75 less than the normal. The greatest monthly amount was 6.47, at Whitesburg, and the least, 2.77, at Ramsey. The month was generally mild and pleasant.

Idaho.—The mean temperature was 27.6°. The highest temperature was 62°, at Lewiston on the 27th, and the lowest, 25° below zero, at Junction on the 13th. The first half of the month the usual January weather as regards temperature prevailed, but with the 15th came a succession of chinook* winds which raised the temperature above normal and gave everything a spring-like appearance; in many places plowing was begun. The mean daily temperature for the last two weeks was 12° higher than that of the first half. The average precipitation was 2.92; the greatest amount was 7.85, at Soldier, and the least, 0.07, at Junction. From the 14th to the 21st rainfall was general and greatly above normal. Mr. Frank Adams, observer at Salubria, says: "For several days this month this section was visited by the heaviest and most constant downpours of rain that have ever occurred within the memory of the oldest inhabitant of this valley; travel of all kinds was suspended for 48 hours. The heavy rise of water on the 20th caused the low lands to be about five feet under water, doing considerable damage, washing out six reservoirs and three bridges, and spoiling a considerable amount of hay throughout this section of the country."

*[NOTE.—The word "chinook" is now used in Idaho to designate any warm wind, including warm southwest rain winds; but such usage is contrary to meteorological authority, and will not be adopted in the MONTHLY WEATHER REVIEW. An indiscriminate use of this word has also sprung up in the Mississippi Valley. The technical usage of professional meteorology is the only one that can be allowed in the MONTHLY WEATHER REVIEW. For the present, therefore, the term "chinook" will only be applied to those winds that can be distinctly proven to be warm, dry, descending winds, and as the term "fœhn" has not yet been misapplied by American newspaper usage, that word will be preferred. We can not have an exact science of meteorology unless our words have an exact signification and are used with precision.—C. A.]